Potential Difference between two Point Charges

Now consider a new quantity, the **electric potential** (**V**) of a charge **q** at a distance **R** away from another charge **Q**. Electric potential is simply the potential energy of the charge **q** per elementary charge due to the electric field of **Q**.

At any location away from a point charge, the electric potential can be determined by

$$\mathbf{V} = \frac{\mathbf{E_p}}{\mathbf{q}} = \mathbf{k}\frac{\mathbf{qQ}}{\mathbf{R}} \mathbf{x} \frac{\mathbf{1}}{\mathbf{q}} \quad \rightarrow \quad \boxed{\mathbf{V = k}\frac{\mathbf{Q}}{\mathbf{R}}}$$

→ where **V** is measured in **Volts** or **Joules/Coulomb**

Note that electric potential is a scalar quantity, much like potential energy. Its magnitude depends on:

- the size of the charge **Q** you are examining;
- the *sign* of the charge (+ or -);
- the location away from the charge, i.e., distance **R**.

A similar quantity, **potential difference**, is defined as the work needed to move a charge of one Coulomb from one location to another in the presence of a field or the work released if the field acts to move the one Coulomb of charge.

Therefore, **potential difference** or **voltage** ($\mathbf{V_{ab}}$ or $\Delta\mathbf{V}$) is simply the *change* in potential energy (or work done) per coulomb of charge as a charge moves between two locations **a** and **b** in an electric field. That is,

$$\boxed{\Delta\mathbf{V} = \frac{\Delta\mathbf{E_p}}{\mathbf{q}}}$$

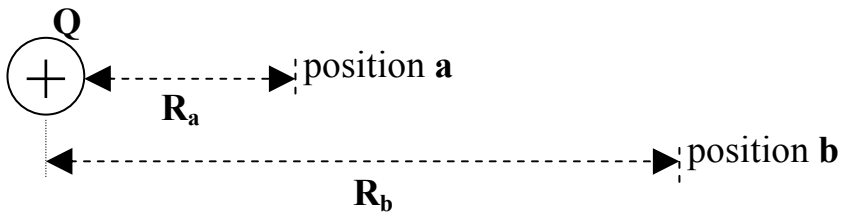
Note that since $\mathbf{\Delta E_p = W = Fd}$, the above equation can be rewritten as

$$\Delta\mathbf{V} = \frac{\mathbf{Fd}}{\mathbf{q}} \quad \rightarrow \text{ and since } \quad \mathbf{E} = \frac{\mathbf{F}}{\mathbf{q}} \text{ (on your formula sheet),}$$

$$\Delta\mathbf{V} = \mathbf{Ed} \qquad \text{or} \qquad \boxed{\mathbf{E} = \frac{\Delta\mathbf{V}}{\mathbf{d}}}$$

This formula provides an alternate method to calculate *electric field strength*, with units being Volts/metre (V/m).

To find the potential difference between two locations **a** and **b** in an electric field:

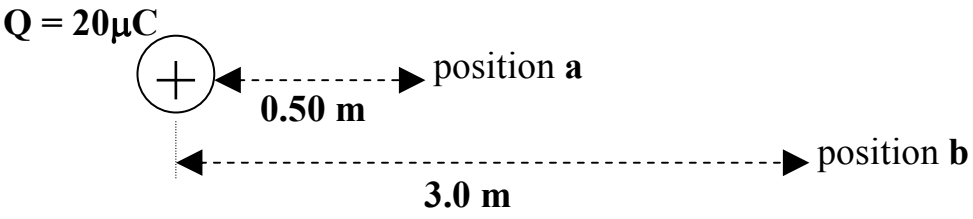


$\Delta V = V_{ab} = V_b - V_a$ where $V = k\frac{Q}{R}$ $\rightarrow \Delta V = V_{ab} = k\frac{Q}{R_b} - k\frac{Q}{R_a}$

Remember, to get work done to move another charge **q** from **Q**, use:

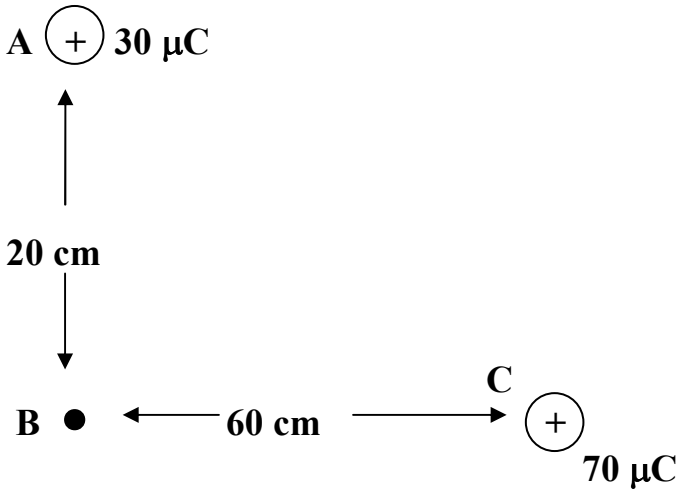
$$W = \Delta E_p = q\Delta V$$

Example 11. What is the potential difference between the two positions in the following example?



(see Electrostatics Ex 11 for answer)

Example 12. Re-examine the diagram from Example 8 (see below). Find the electric potential at point B due to the other charges. Hint: remember, electric potential is a scalar quantity. No vector analysis is needed here.



(see Electrostatics Ex 12 for answer)